

WHAT IS CLAIMED IS:

- 1                   1.       A method of forming a silicon oxide layer over a substrate  
2 disposed in a substrate processing chamber, the method comprising:  
3                   flowing a process gas a silicon-containing gas, an oxygen-containing gas  
4 and a fluorine-containing gas that is different from the silicon-containing gas into the  
5 substrate processing chamber;  
6                   depositing the silicon oxide layer over the substrate by forming a high  
7 density plasma from the process gas and biasing the plasma towards the substrate to  
8 generate a sputter etching component simultaneous with film deposition, wherein the  
9 substrate is heated to a temperature of at least 500°C during deposition of the silicon  
10 oxide layer and wherein the deposited silicon oxide layer has a fluorine content of 1.0  
11 at. % or less as measured by using Secondary Ion Mass Spectrometry (SIMS)  
12 techniques.
- 1                   2.       The method of claim 1 wherein the sputtering element of the  
2 deposition process slows deposition on corners of raised surfaces the silicon oxide layer  
3 is deposited over thereby contributing to an increased gapfill capability of the silicon  
4 oxide layer.
- 1                   3.       The method of claim 1 wherein the substrate is heated to a  
2 temperature of between 650-750°C during deposition of the silicon oxide layer and the  
3 silicon oxide layer is used to at least partially fill a trench etched as part of a shallow  
4 trench isolation structure.
- 1                   4.       The method of claim 1 wherein said silicon oxide layer has a  
2 fluorine content of 0.6 at. % or less.
- 1                   5.       The method of claim 4 wherein the silicon-containing gas  
2 comprises SiH<sub>4</sub>.
- 1                   6.       The method of claim 5 wherein the fluorine-containing gas  
2 comprises NF<sub>3</sub>.
- 1                   7.       The method of claim 6 wherein the oxygen-containing source  
2 comprises O<sub>2</sub>.

- 1                    8.        The method of claim 6 wherein the silicon oxide layer is an  
2 undoped silicate glass layer (USG).
- 1                    9.        The method of claim 6 wherein the silicon oxide layer is doped  
2 with phosphorus and the process gas further comprises a phosphorus-containing gas.
- 1                    10.      The method of claim 9 wherein said phosphorus-containing gas  
2 comprises PH<sub>3</sub>.
- 1                    11.      The method of claim 1 wherein the process gas further comprises  
2 an inert gas.
- 1                    12.      The method of claim 11 wherein the inert gas comprises argon.
- 1                    13.      The method of claim 1 further comprising forming a thin layer of  
2 silicon oxide material from a process gas that does not include the fluorine-containing  
3 gas prior to introducing the fluorine-containing gas into the process gas.
- 1                    14.      The method of claim 1 wherein the silicon-containing gas is  
2 introduced into the chamber from gas nozzles surrounding the substrate and from above  
3 the substrate.
- 1                    15.      The method of claim 14 wherein the oxygen-containing gas is  
2 introduced only from nozzles surrounding the substrate.
- 1                    16.      The method of claim 15 wherein the fluorine-containing gas is  
2 introduced only from nozzles surrounding the substrate.
- 1                    17.      A method of forming a silicon oxide layer over a substrate  
2 disposed in a substrate processing chamber, the method comprising:  
3                    flowing a process gas a silicon-containing gas, an oxygen-containing gas  
4 and a fluorine-containing gas that is different from the silicon-containing gas into the  
5 substrate processing chamber;  
6                    depositing the silicon oxide layer over the substrate by forming a high  
7 density plasma from the process gas and biasing the plasma towards the substrate to  
8 generate a sputter etching component simultaneous with film deposition, wherein the  
9 substrate is heated to a temperature of at least 650°C during deposition of the silicon

10 oxide layer and wherein the deposited silicon oxide layer has a fluorine content of 0.6  
11 at. % or less as measured by using Secondary Ion Mass Spectrometry (SIMS)  
12 techniques.

1 18. The method of claim 17 wherein the sputtering element of the  
2 deposition process slows deposition on corners of raised surfaces the silicon oxide layer  
3 is deposited over thereby contributing to an increased gapfill capability of the silicon  
4 oxide layer.

1 19. The method of claim 18 wherein the silicon oxide layer is used to  
2 at least partially fill a trench etched as part of a shallow trench isolation structure.

1 20. The method of claim 17 wherein the silicon-containing gas  
2 comprises  $\text{SiH}_4$ .

1 21. The method of claim 20 wherein the fluorine-containing gas  
2 comprises  $\text{NF}_3$ .

1 22. The method of claim 21 wherein the oxygen-containing source  
2 comprises  $\text{O}_2$ .

1 23. The method of claim 17 wherein the silicon oxide layer is an  
2 undoped silicate glass layer (USG).

1 24. The method of claim 17 wherein the silicon oxide layer is doped  
2 with phosphorus and the process gas further comprises a phosphorus-containing gas.

1 25. The method of claim 24 wherein said phosphorus-containing gas  
2 comprises  $\text{PH}_3$ .

1 26. The method of claim 21 wherein the process gas further  
2 comprises an inert gas.

1 27. The method of claim 26 wherein the inert gas comprises argon.

1 28. The method of claim 17 further comprising forming a thin layer  
2 of silicon oxide material from a process gas that does not include the

3 fluorine-containing gas prior to introducing the fluorine-containing gas into the process  
4 gas.

1                   29.     The method of claim 17 wherein the silicon-containing gas is  
2 introduced into the chamber from gas nozzles surrounding the substrate and from above  
3 the substrate.

1                   30.     The method of claim 17 wherein the oxygen-containing gas is  
2 introduced only from nozzles surrounding the substrate.

1                   31.     The method of claim 17 wherein the fluorine-containing gas is  
2 introduced only from nozzles surrounding the substrate.